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LARGE-CROWNED PLANTED PONDEROSA PINE RESPOND WELL TO THINNING

by

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ABSTRACT

Sizable reductions in growing stock are feasible in overstocked ponderosa pine plantations where tree crowns are well formed and full. Thirty-year-old planted stands thinned to 140 trees per acre produced about the same volume as similar thinned stands containing four times as many trees. Understory vegetation in this study did not offer the severe competition to tree growth that was observed in brush areas near Bend, Oregon, and stands produced 70 to 90 cubic feet annually 5 years after thinning. Trees at the widest spacing (17.6 by 17.6 feet) grew in diameter at an average rate of 2.7 inches per decade, and those at narrowest spacing (8.8 by 8.8 feet) grew less than 1 inch per decade. Height growth was not affected by thinning intensity.

Keywords: Thinning (trees), stand density, ponderosa pine, forest improvement cutting.

Thinning study results provide a portion of the information on which timber stand improvement policy is formulated. To be useful these studies should sample a wide range of sites, tree sizes, age classes, and geographic locations in planted and natural stands.

The study reported here is one of a number of thinning experiments established in various stands throughout the Pacific Northwest during the period from 1957 to 1965. This report summarizes initial 11-year results after thinning a 33-year-old ponderosa pine plantation.[1]

STAND HISTORY

The study area is bisected by an intermittent stream drainage called Flat Creek near the middle fork of the John Day River, 25 miles northeast of John Day, Oregon. The stand was established by planting in the springs of 1925 and 1926 after logging and a hot burn. The planting stock was 1-1 and 2-1 from the Wind River nursery located near Carson, Washington. Seed source is uncertain but is believed to have come from the Wallowa-Whitman National Forest. Seedlings were planted with a hoe at a spacing of 6 by 6 feet. On one side of the drainage, slopes are steep with a northeast exposure; on the other, gentle south slopes predominate. Average elevation is about 4, 100 feet.

Early records and photographs indicate that understory vegetation offered little competition to tree growth during the early history of this plantation. Thinning has not appeared to increase growth of competing vegetation appreciably even at the wide spacings. Some scattered *Ribes* bushes may have responded slightly to thinning, but they are so few their competitive effect seems negligible. Few grasses were found on the area, and those present were grazed so heavily that identification was difficult. Other genera occurring on the plantation are *Berberis* (Oregon grape), *Vaccinium* (huckleberry), *Arctostaphylos* (kinnikinnick), *Fragaria* (strawberry), *Rosa* (rose), *Potentilla* (cinquefoil), and *Antennaria* (everlasting). The plant community was identified as mixed conifer/*Calamagrostis*.[2] Thus, an entirely different understory vegetation complex exists on this study than on the thinning study near Bend, Oregon[3] where shrub species bitterbrush, manzanita, and snowbrush make up the *Pinus ponderosa/Purshia tridentata-Arctostaphylos patula* plant community.

The surface soils on the study plots have developed on wind-deposited talus-parent materials. Where the wind-deposited parent materials occur, two buried profiles are present. One profile is developed on wind-deposited material, while a lower, older profile appears to be a residual soil. Textures for horizons developed on wind-deposited parent material range from clay loams to loams, while textures in the oldest buried soil are clay loams and silty clays. Talus parent materials occur mainly on northeast exposures where 5-foot profiles consisted of 70 percent stone. Plots on southern exposures have soils containing only 2 to 5 percent stone. This stone exists in the residual parent material and as outcropping from the residual parent material. Sometimes this stone extends up into the wind-deposited parent material.

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[1] A cooperative research effort between the Malheur National Forest and the Pacific Northwest Forest and Range Experiment Station.

[2] Plant community identified by Frederick C. Hall, Region 6, U.S. Forest Service.

[3] James W. Barrett. Ponderosa pine saplings respond to control of spacing and understory vegetation. USDA Forest Serv. Res. Note PNW-106, 16 p., illus. Pac. Northwest Forest & Range Exp. Stn., Portland, Oreg. 1970.

THE STUDY

Spacings tested were 8.8, 10.2, 12.5, and 17.6 feet (figs. 1 and 2). Each spacing was replicated three times in a randomized block design making a total of 12 plots. Plots consisted of 0.1-acre squares (66 feet by 66 feet), surrounded by a 33-foot buffer strip.

Spacings selected are based on attaining 100, 75, 50, and 25 percent of normal basal area (site index 78)[4] when the average diameter of the stand reaches 8 inches. It was assumed that an 8.8 by 8.8 spacing of 560 well-spaced 8-inch trees per acre would occupy the site rapidly and represent the land's capacity to produce wood fiber, i.e., this high density treatment was to represent a production goal with which to compare the three wider spacings.

In 1959, directly after thinning, five trees per plot were climbed and stem diameter measured at 10-foot intervals to form the basis for a volume equation. In 1965, these same trees plus five more per plot were measured. During the first period, volume was determined by combining all climbed trees (60) into one equation defining volume as a function of diameter and height (D^2H, D^3H, and H^2). During the last period, separate equations were computed for each plot based on 10 climbed trees per plot.

Diameter at breast height and height of all trees on each plot were measured to the nearest 0.1 inch and 0.1 foot, respectively.

Analysis of variance was used to judge treatment effect. Attempts to use stoniness and initial height of the 100 largest trees as covariates failed. Evidently site differences were taken care of by block distinction when the study was installed. Stone content was high on the northeast exposure which made up a block of four plots.

Trees left after thinning were vigorous, full-crowned trees (fig. 3). They contrasted sharply with poorly crowned trees found in adjacent dense natural stands where trees had been subjected to years of suppression.

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[4] Walter H. Meyer. Yield of even-aged stands of ponderosa pine. U.S. Dep. Agric. Tech. Bull. 630 (rev.), 59 p., illus. 1961.

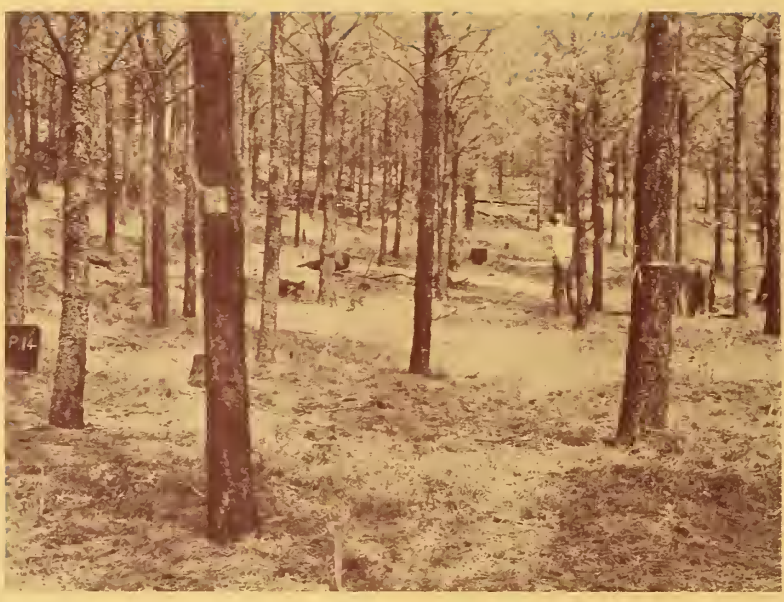

Figure 1.—Stand thinned to 10.2- by 10.2-foot spacing, or 420 trees per acre.

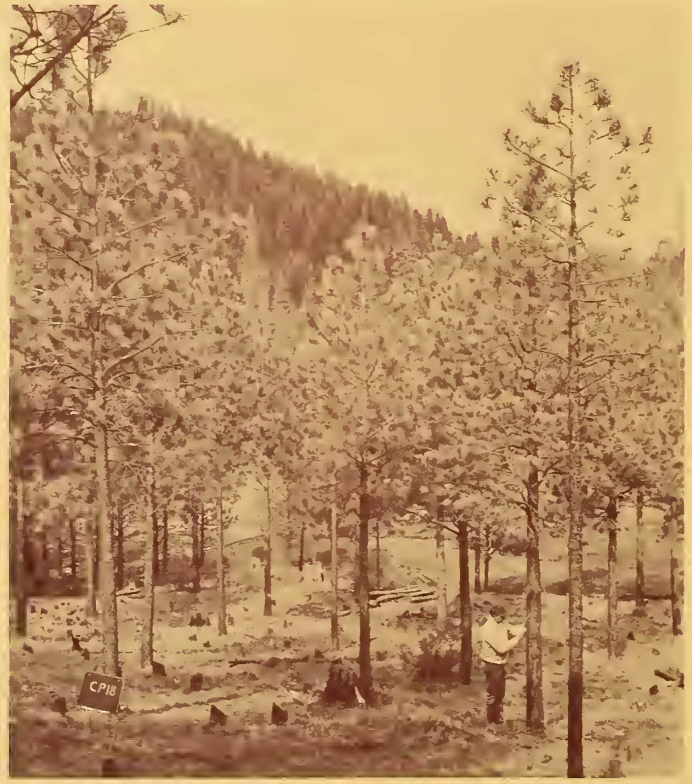

Figure 2.—Stand thinned to 17.6- by 17.6-foot spacing, or 140 trees per acre.

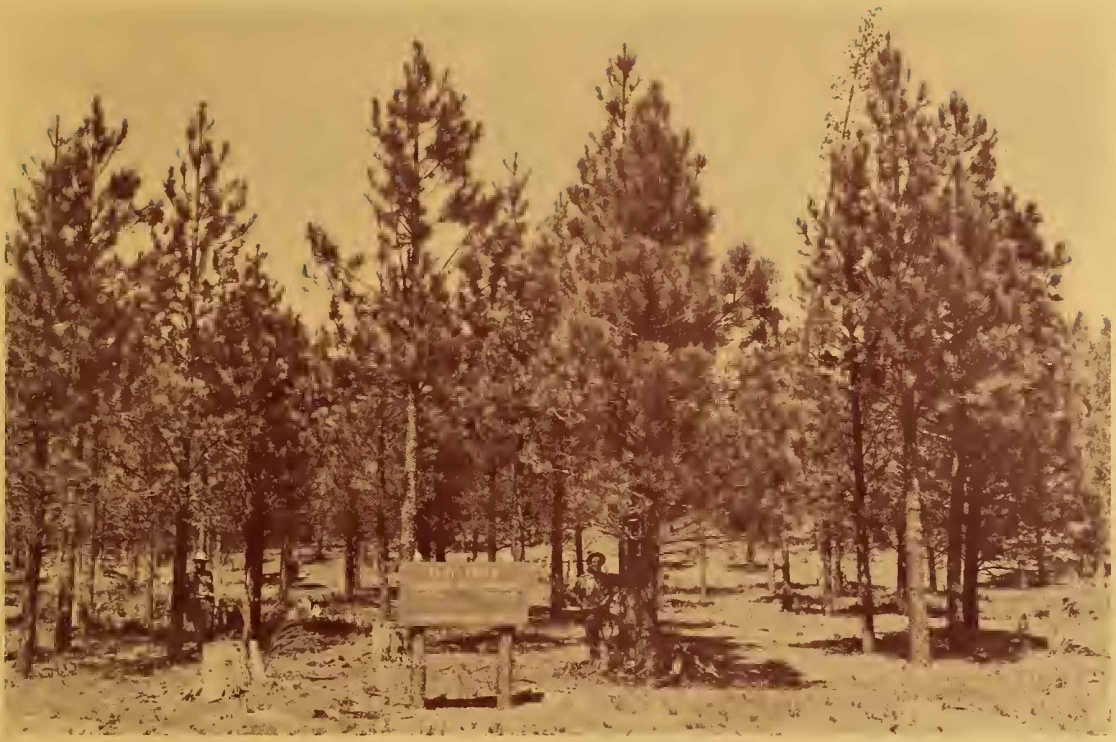

Figure 3.—Most trees left after thinning were full-crowned and capable of responding to the additional growing space provided by thinning.

RESULTS

Directly after thinning, trees averaged 5.5 inches in diameter at the closest spacing and 6.8 inches at the widest (table 1). Basal areas ranged from 92 square feet per acre at the highest density to 35 at the lowest and heights, from 23 to 26 feet. Stands with the closest spacing contained 886 cubic feet per acre compared with only 383 at the widest.

Diameter Growth

Widely spaced trees grew significantly better than narrowly spaced ones during the first and second periods of observation (fig. 4). Also, rate of diameter growth was significantly greater during the second period than during the first. Trees at the widest spacing (17.6 feet) grew at the rate of 2.7 inches per decade during the second period compared with only 1.0 inch for trees 8.8 feet apart.

Individual tree growth ranged from a high of 0.4 inch per year on full-crowned widely spaced trees to no detectable amount on poor-crowned trees at high densities.

Examination of the growth of the 100 largest diameter trees per acre

Table 1.--*Average live stand characteristics per acre directly after thinning, and 6 years and 11 years later*

Treatment		Age	Diameter[1]		Height[2]		Basal area	Bole area	Volume[3]
Spacing (feet)	Trees per acre		All trees	100 largest trees	All trees	100 largest trees			
		Years	*- - Inches - -*		*- - Feet - -*		*Sq. ft.*	*1,000 sq.ft.*	*Cu. ft.*
8.8	560	33	5.5	7.4	22.6	28.5	92.4	10.3	886
		39	6.1	8.2	26.1	33.2	113.6	12.4	1,161
		44	6.6	9.0	30.0	37.8	133.1	15.4	1,605
10.2	420	33	5.7	6.6	20.6	25.2	74.4	7.8	580
		39	6.3	7.4	23.8	29.9	90.9	9.4	739
		44	7.0	8.2	27.1	33.9	112.3	12.1	1,105
12.5	280	33	6.1	6.8	21.8	25.6	56.8	5.8	458
		39	6.8	7.6	25.3	29.7	70.6	7.6	643
		44	7.7	8.5	29.3	34.3	90.6	10.4	1,018
17.6	140	33	6.8	7.4	26.4	28.1	35.3	3.7	383
		39	7.9	8.6	30.7	32.8	47.7	4.7	560
		44	9.3	10.0	35.7	38.2	66.0	6.7	931

[1] Quadratic mean.

[2] Arithmetic mean.

[3] Volume of entire stem inside bark.

shows that growth of these trees was reduced by competition from other trees (fig. 5). For example, the 100 largest trees in the two highest densities grew an average of about 1.4 inches during the first and second periods, compared with 2.0 in the first period and almost 3.0 inches in the second period at the widest spacing.

Height Growth

The effect of spacing on height growth varied (fig. 6). Although trees on the widely spaced plots grew an average of about 1 foot per year during the second period, growth on one plot at the narrowest spacing nearly equaled this. Similar conclusions were drawn when considering only the 100 largest trees per acre (fig. 7).

Height growth averaged greater during the second period for all treatments, although no statistical significance could be attributed to the increase. Three plots grew slightly less during the second period than during the first. Individual tree increments ranged from a high of 1.6 feet per year on several trees at the widest spacing to 0.2 foot on some trees at the narrowest spacing. Great variation in individual tree height growth was observed within plots, and growth appeared more closely related to initial tree size directly after thinning rather than to stand treatment.

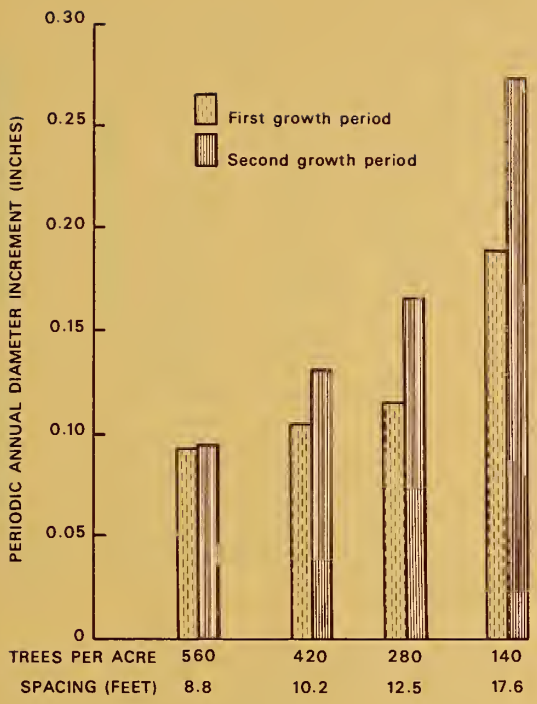

Figure 4.—Average annual diameter increment of all ponderosa pine during the first and second growth periods.

The 100 largest trees from the stand grew substantially more than the stand average at the higher densities, but, as before, treatment did not affect growth (fig. 7).

Mortality

Only five of the 420 trees in the experiment died during the 10-year period of observation. Four of these trees died on plots with the closest spacing where a few suppressed trees had to be left to meet the specified density. This mortality amounted to about 0.9 of a cubic foot per acre per year. There was no mortality at the widest spacing.

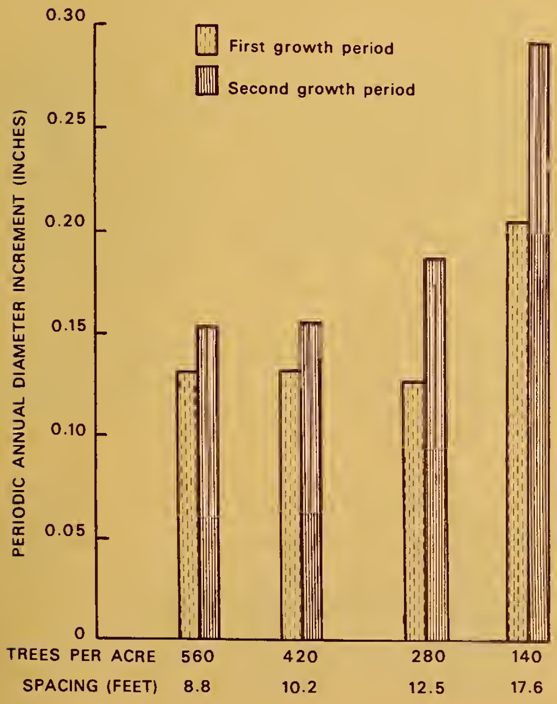

Figure 5.—Average annual diameter increment of the 100 largest diameter trees per acre during the first and second growth periods.

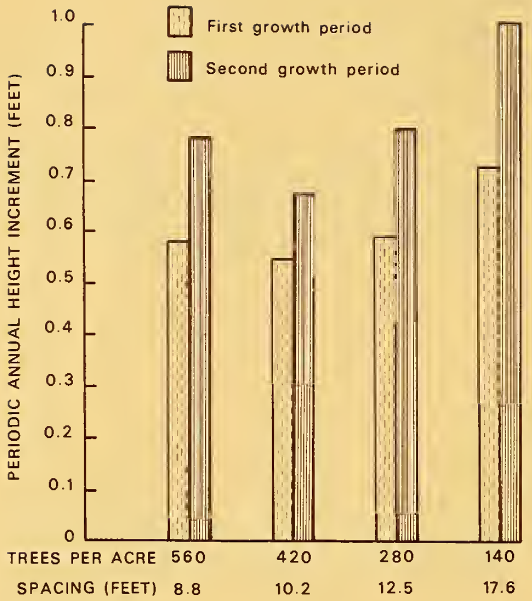

Figure 6.—Average annual height increment of all trees during the first and second growth periods.

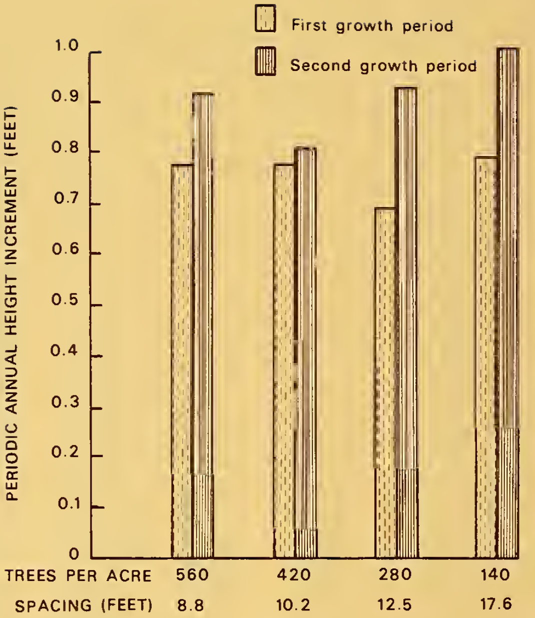

Figure 7.—Average annual height increment of the 100 largest trees per acre during the first and second growth periods.

Cubic Volume Increment

Thinning treatment did not significantly affect cubic volume increment in either period of observation (fig. 8). One hundred forty trees per acre has produced at least 80 percent of the cubic volume grown by 560 trees per acre; thus the capacity of the stand to produce volume has been transferred from many small trees to fewer large trees.

During the first period, the highest density produced about 46 cubic feet per acre per year, with the other three densities producing between 26 and 31 cubic feet. During the last period, roots and crowns probably expanded sufficiently to take better advantage of the additional growing space, and there was a highly significant increase in production from the first to the second period. The highest density averaged about 89 cubic feet per acre per year, with the other three densities averaging 73 to 75 cubic feet.

Extreme soil stoniness probably contributed to reduced wood production on two plots in this experiment. Volume increment on one plot containing 75 percent stone (fig. 9B) was 50 percent lower than the comparable figure for

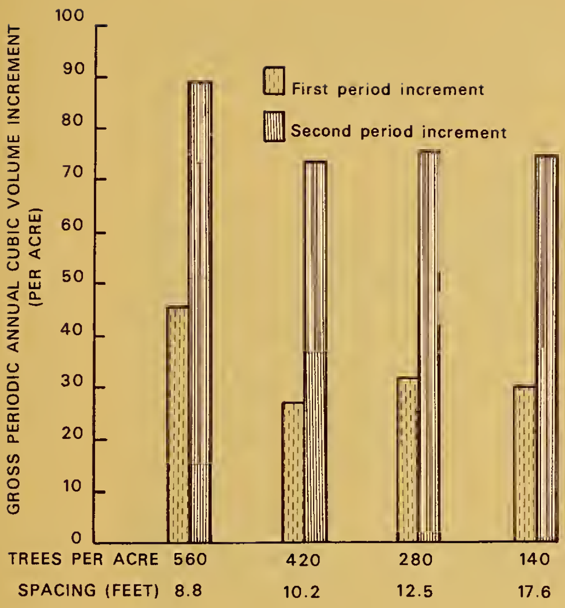

Figure 8.—Periodic annual gross volume increment of ponderosa pine thinned to various spacings during the first and second growth periods.

plots thinned to the same density but situated on stone-free soil. Although the thinned stands on very stony soils appear healthy and vigorous (fig. 9A), volume production was markedly reduced. Evidently stoniness has so lowered soil moisture storage capacity that trees on these sites are deprived of adequate soil water for optimum growth.[5] This condition was evident in reduced height growth where average initial height on stony soil plots was about 6 feet shorter than plots with low stone content.

Understory vegetation on this site is not providing the severe competition to tree growth reported for a comparable study near Bend, Oregon.[6] This may be due, in part, to heavy grazing since this study is located close to water. In the present study there was significant trend toward more increment for the largest trees as stand density was decreased (fig. 10). For example, the 100 largest trees, in a stand containing 420 trees per acre, grew at the rate of 33 cubic feet per acre per year, and this increased to 45 and 63 cubic feet in stands containing only 280 and 140 trees. However, in central Oregon where shrubs are more abundant, wide spacing stimulated understory vegetation which offered as much competition as many more trees. In the present study, understory competition appears to be almost negligible since the growth curves in figure 10 have a fairly smooth upward trend with decreasing density. If invading understory vegetation were serious competition, growth curves in figure 7 would be expected to be more nearly flat, as reported by Barrett.[7]

It should be recognized, however, that soils of the study reported here and the one in central Oregon are quite different. The latter occurs on a dacite

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[5] C. T. Dyrness. Hydrologic properties of soils on three small watersheds in the western Cascades of Oregon. USDA Forest Serv. Res. Note PNW-111, 17 p., illus. Pac. Northwest Forest & Range Exp. Stn., Portland, Oreg. 1969.

[6] See footnote 3.

[7] See footnote 3.

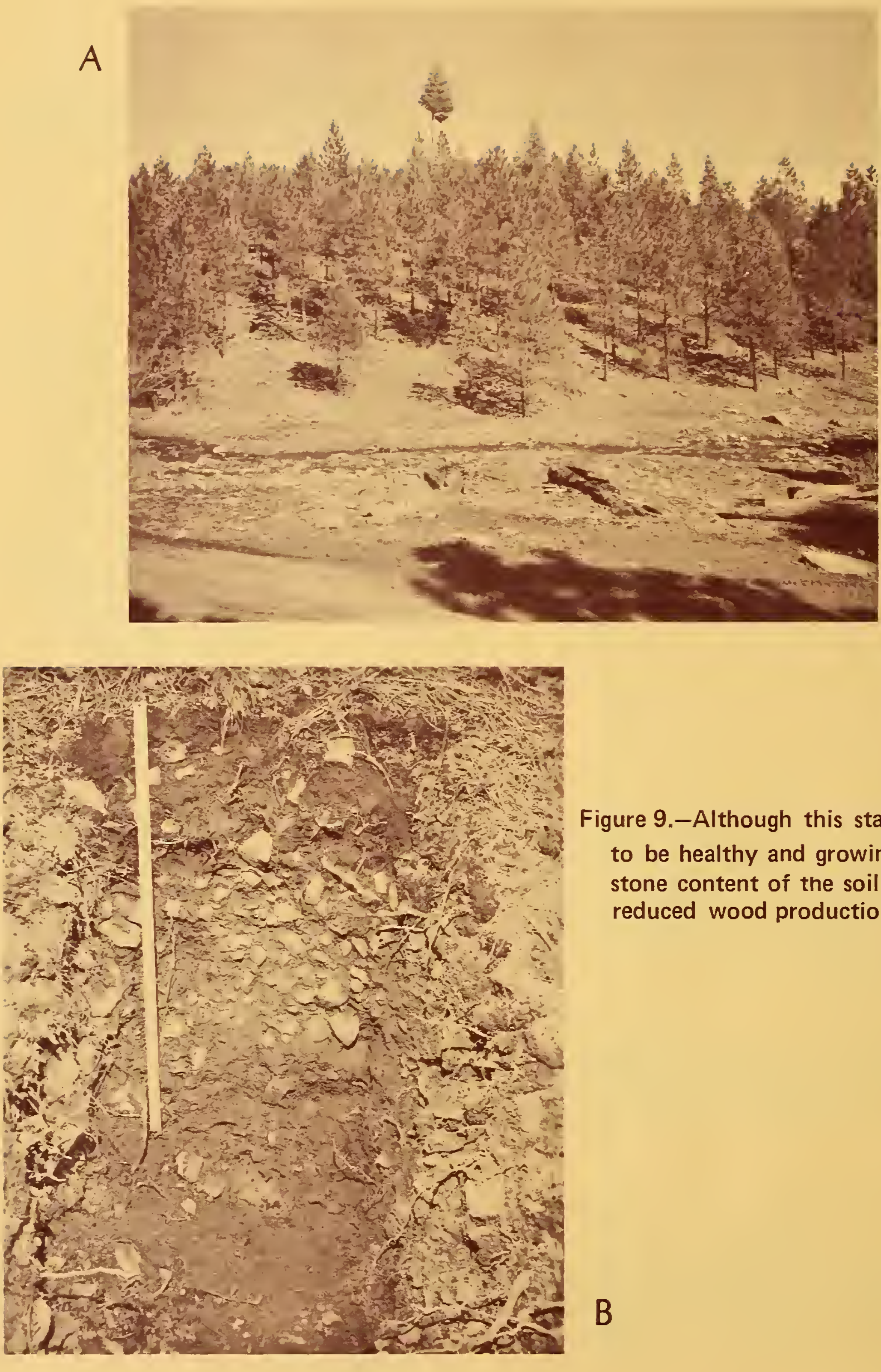

Figure 9.—Although this stand appears to be healthy and growing well (A), stone content of the soil may have reduced wood production (B).

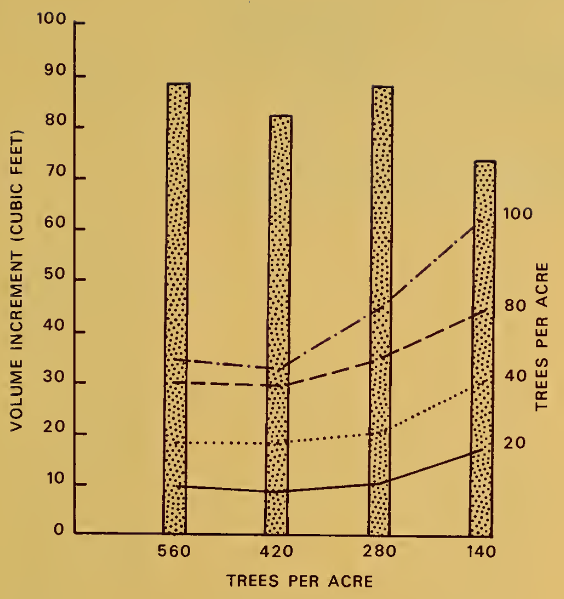

Figure 10.—Periodic annual volume increment of ponderosa pine saplings thinned to various spacings (1965-69). Bars show increment for total number of trees at each spacing. Points within bars show increment of the stated number of the largest well distributed trees within the stand. (Volume increment for the 420 and 280 trees per acre treatments does not agree with that shown in figure 8 because data from the two plots containing large amounts of stone were excluded from averages.)

pumice mantle averaging 33 inches thick underlain by a sandy loam Paleosol. Some of the horizons of the pumice mantle are rather sterile, and the moisture characteristics of the two soils on the two study areas are probably quite different. Therefore, some of the growth difference between the two studies may be explained by factors other than competition from invading vegetation.

DISCUSSION AND CONCLUSIONS

This demonstration suggests that wood production in ponderosa pine plantations, where tree crowns are well formed and full, recovers rapidly after thinning even though only 140 trees per acre are left. Furthermore, this experiment supports the theory that in vigorous young stands the same amount of periodic annual cubic volume can be produced over a wide range of tree densities. Although the heaviest thinning constituted an initial reduction in basal area of 65 percent, this treatment produced 80 percent of the volume grown by four times as many trees. Even more important is the fact that a commercial thinning will probably be possible in another decade. Basal area will probably have attained 100 square feet and average diameter of the stand should be approaching 12 inches.

The planted ponderosa pines in this experiment have developed without the severe suppressional period experienced by many crop trees in natural stands[8] and have therefore been able to respond quickly to thinning. Foresters should be cautious about applying growth results reported here to thinned natural stands with short, suppressed crowns. Once trees in thinned natural stands have recovered from the suppressional period, spacing-growth relationship between the two stands should be similar.

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[8] James W. Barrett. Dominant ponderosa pines *do* respond to thinning. USDA Forest Serv. Res. Note PNW-9, 8 p., illus. Pac. Northwest Forest & Range Exp. Stn., Portland, Oreg. 1963.

The dense parts of this plantation should have been thinned at an earlier age to maintain a reasonable diameter growth. Before thinning and where little mortality had taken place, diameter growth rates were less than 1 inch per decade. Outside the study area where spacing was much wider than 6 by 6 feet, average tree diameters were sometimes twice that found in the stand, with negligible mortality. Thus planting fewer trees would probably have resulted in a much larger average tree at age 33.

Planting ponderosa pine on excessively stony soil does not appear to be an economically sound practice when wood production is the principal objective. It is doubtful that a merchantable log will ever be produced in a reasonable length of time on these extremely stony soils. On the other hand, such land uses as watershed, recreation, and wildlife may justify the expenditure for reforestation.

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